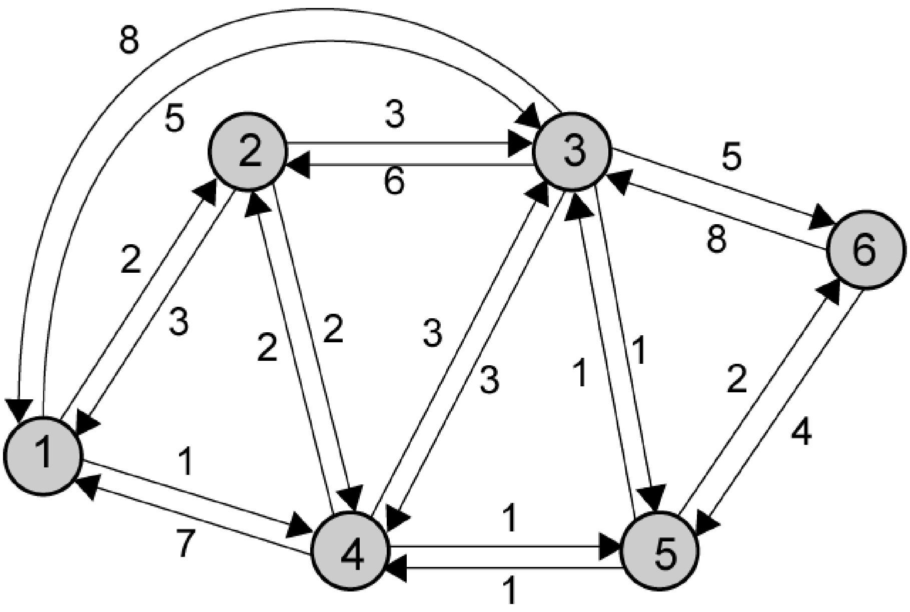
Adaptive Routing

1. Given a network in following figure, obtain shortest path routes from node 6 to all the other nodes in the network. Use Dijkstra and Bellman-Ford algorithms.



Dijkstra: starting from node 2.

	M	L(1)	Path	L(2)	Path	L(3)	Path	L(4)	Path	L(5)	Path
1	{6}	∞	—	∞	—	8	6-3	∞	—	4	6-5
2	{6, 5}	∞	—	∞	—	5	6-5-3	5	6-5-4	4	6-5
3	{6, 5, 3}	13	6-5-3-1	8	6-5-3-2	5	6-5-3	5	6-5-4	4	6-5
4	{6, 5, 3, 4}	12	6-5-4-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5
5	{6, 5, 3, 4, 2}	10	6-5-4-2-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5
6	{6, 5, 3, 4, 2, 1}	10	6-5-4-2-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5

Bellman-Ford: starting from node 2

h	$L_h(1)$	Path	$L_h(2)$	Path	$L_h(3)$	Path	$L_h(4)$	Path	$L_h(5)$	Path
0	∞	—	∞	—	∞	—	∞	—	∞	—

1	∞	—	∞	—	8	6-3	∞	—	4	6-5
2	16	6-3-1	14	6-3-2	5	6-5-3	5	6-5-4	4	6-5
3	12	6-5-4-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5
4	10	6-5-4-2-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5
5	10	6-5-4-2-1	7	6-5-4-2	5	6-5-3	5	6-5-4	4	6-5

2. Suppose a routing algorithm identifies paths that are "best" in the following sense: (1) minimum number of hops, (2) minimum delay, or (3) maximum available bandwidth. Identify the conditions under which the paths produced by the different criteria are the same? Are different?

The first criterion ignores the state of each link, but works well in situations were the states of all links are the same. Counting number of hops is also simple and efficient in terms of the number of bits required to represent the link. Minimum hop routing is also efficient in the use of transmission resources, since each packet consumes bandwidth using the minimum number of links.

The minimum delay criterion will lead to paths along the route that has minimum delay. If the delay is independent of the traffic levels, e.g. propagation delay, then the criterion is useful. However, if the delay is strongly dependent on the traffic levels, then rerouting based on the current delays in the links will change the traffic on each link and hence the delays! In this case, not only does the current link delay need to be considered, but also the derivative of the delay with respect to traffic level.

The maximum available bandwidth criterion tries to route traffic along pipes with the highest "cross-section" to the destination. This approach tends to spread traffic across the various links in the network. This approach is inefficient relative to minimum hop routing in that it may use longer paths.

At very low traffic loads, the delay across the network is the sum of the transmission times and the propagation delays. If all links are about the same length and bit rate, then minimum hop routing and minimum delay routing will give the same performance. If links vary widely in length, then minimum hop routing may not give the same performance as minimum delay routing.

Minimum hop routing will yield the same paths as maximum available bandwidth routing if links are loaded to about the same levels so that the available bandwidth in links is about the same. When link utilization varies widely, maximum available bandwidth routing will start using longer paths.

Note: Students may have different answers.

3. **It was shown that flooding can be used to determine the minimum-hop route. Can it be used to determine the minimum-delay route**?

No. Let's take the example of figure in Q2 (ii), the minimum hop route from 1 to 6 is 1-3-6 and the minimum delay route is 1-4-5-6. Although it is true that the first packet to reach node 6 has experienced the minimum delay, this delay was experienced under a condition of network flooding, and cannot be considered valid for other network conditions.

Yes. The flooding traffic might be negligible as compared to real network traffic. In that case, it can be used to find the minimum-delay route.